

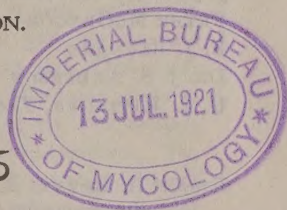
Flora H. Patterson

THE STATE COLLEGE OF WASHINGTON

THE AGRICULTURAL
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Department of Botany and Zoology

Apple Scab in Eastern Washington

By W. H. Lawrence

1906

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Apple Scab in Eastern Washington

By W. H. Lawrence

The results obtained in studying the structure and life history of the fungus that causes apple scab as it occurs in Western Washington and some experimental work done in combatting it were published in Bulletin No. 64 of this Station. Some additional work has recently been done on the disease as it occurs in the Eastern part of the state. A comparison of the efficiency of liquid bordeaux (Bordeaux mixture) and dust bordeaux (dry bordeaux mixture with lime dust as a carrier) has been the principal line of work in the later investigations. The general development of the fungus has been noted but no additional work has been done on the life history. It is evident that the life history varies but little in the numerous sections in which it occurs. The most important variation is the time of distribution of the winter spores. This slight change in time of distribution of spores varies with the date of the flowering of the apple trees. The growth of the apple tree then determines the dates on which the sprays should be applied.

THE FUNGUS.

In 1894 and later, Aderholt made a careful study of the fungus and demonstrated beyond question that two distinct forms alternate in the round of life, (Landw. Jahrb. 25, pp. 880-897. 1896). Clinton verified the work for the state of Illinois in 1901, (Bull. 67), and the writer carried out the same line of work in this state in 1903 (Bull. 64.) The latter verifications confirm the results obtained by Aderholt. These studies have shown that the parasitic stage (*Fusicladium dendriticum*) which is commonly called apple scab is only the summer stage of the saprophytic fungus (*Venturia inaequalis*) which lives in the decaying leaves of the apple tree during the winter. This stage is also called the winter stage.

WINTER STAGE.

The fungus in the diseased leaves continues to grow during the winter. Sometime in late winter or early spring capsules are formed inside these leaves. Each capsule contains several little sacs each of

which usually contains eight spores. About the time the new leaves begin to unfurl in spring and later these spores escape from the capsules and float about in the air. Some of them lodge on the young leaves, flowers and fruit. If they germinate the germ tubes enter the parts with which they come in contact and cause them to become diseased. The summer stage then soon makes its appearance.

SUMMER STAGE.

In a few days small, usually nearly circular spots of a dark olive green color appear. The olive green mass is composed of very numerous short, small stalks on the tips of which the summer spores are borne. The summer spores mature at once and drop off. If they lodge on the leaves and fruit of the same tree or a neighboring one, they will cause new areas to become diseased. Very shortly a second crop of summer spores is produced by the fungus in the new areas and these in turn drop off. Some of them are carried by the wind and other agents to the leaves and fruit and thus spread the disease more widely. Summer spores mature in such a short time and are produced in such abundance that thousands of scabby spots appear in the course of a few days when conditions are favorable.

SPREAD OF THE DISEASE.

While the leaves are still young and tender and the fruit is just beginning to form, conditions are usually favorable for a rapid spread of the disease. As the parts mature the new spots become less frequent and finally cease to appear. The greater number of these areas appear during the interval between the unfolding of the leaves and a few days after the petals have fallen. Germination tests made with the summer spores show that the summer spores will germinate much later in the season than after the last spots appear. The reason that the fungus no longer produces new diseased areas is perhaps due to the epidermis of the leaves and fruit becoming somewhat thicker and firmer and thus more resistant so that the fungus is not able to make an entrance.

DEVELOPMENT OF SCABBY AREAS ON THE LEAVES AND FRUIT.

The general appearance of scabby spots on fruit and leaves is occasionally quite marked. In the fruit the fungus always forms vast numbers of stalks and spores which are borne so closely together that

dark olive green blotches are the result. Similar blotches also occur on the leaves in greater or less abundance. In many cases the fungus spreads throughout a greater portion of the leaf and does not form the blotches but forms lines of stalks bearing the summer spores. These spores are usually some little distance apart and unless observed closely are overlooked. The latter form although abundant often leads one to think that little or no disease is present unless familiar with this mode of development.

SUSCEPTIBILITY OF PARTS ATTACKED.

The resistance of the leaves or fruit of a tree to the disease is frequently very marked. The fruit and leaves on some trees become very badly infested. On other trees the leaves are badly scabbed while the fruit is comparatively free and vice versa.

THE NATURE OF THE INJURY.

The nature and extent of the injury depends upon the abundance of the fungus and the parts attacked. A few small spots on the leaves cause little or no apparent injury. A number of more prominent ones cause them to become wrinkled and folded. Numerous scabby spots may cause them to turn a light yellow color and to fall off early in the season. Scabby spots occur on all parts of the fruit. When the fungus attacks the stem of the apple it may so weaken it that the fruit will fall off. This is particularly true if infection takes place just before or after fertilization or while the fruit is still very small. A few spots on the fruit have no very marked effect.

Prominent scabby spots, especially those in the blossom end cause the fruit to become lopsided. Badly infested areas occasionally become woody and crack open. The best of fruit with a few spots on them, but not otherwise disfigured, will not sell on the market as a first class fruit.

INCREASE OF THE DISEASE.

The disease in the past has not been very important except in and near the wooded areas. The increase has been quite marked during the past season. In the fall of 1904 the per cent of scabby fruit on numerous varieties grown in the station orchard was estimated. Twelve of these varieties were included in a spraying experiment the following spring. The results of this experiment are given elsewhere in this bulletin.

The following table and explanations show the per cent of gain of the disease on the twelve varieties during the past season:

Variety	Percent Scabby		Gain
	1905	1904	
Blood.....	98	50	48
Boyd.....	100	50	50
Md. Maiden Blush.....	87	50	37
McNash.....	99	50	49
Missouri.....	100	20	80
Noble Savori.....	84	15	69
Red June.....	99	35	64
Sops of Wine.....	97	40	57
Stone Eureka.....	100	80	20
Wine.....	97	20	77
Rambo.....	74	5	69
Kronish Rosy.....	5	5	0
Average.....	86	38	52

These varieties were selected as they are quite susceptible and the spots abundant enough to give a good comparison. In 1904 they ranged from 5 per cent to 80 per cent scabby with an average of 38 per cent. A careful count of all the fruit on the trees in fall of 1905 gave a range of 5 per cent to 100 per cent scabby with an average of 86 per cent. This gives a gain of 52 per cent. During the second season the gain in a majority of cases was more than double. This is a much greater average gain than on many other varieties and does not give a fair average increase for all varieties. The table does show, however, that apple scab is on the increase and should receive the attention of the fruit grower.

CONDITIONS FAVORABLE FOR THE GROWTH OF THE FUNGUS.

The remarkable increase of the past season is partly explained by referring to the weather records. The following data, kindly furnished by Prof. Severance, assistant agriculturist of the Station, is taken from the records of the local weather bureau.

Rain and Temperature Record for April and May, 1904 and 1905.

	April							May						
1904—	1-7	8-14	15-21	22-28	29-30	Ave.		1-7	8-14	15-21	22-28	29-31	Ave.	
Average temperature	44	58	49	53	43	49		49	53	54	56	62	55	
Average temperature	49	47	50	54	46	49		56	49	52	53	64	55	
1904—						Tot.							Tot.	
Rainfall.....	.13	.....	.75	.30	.14	1.32		.21	.02	.40	.09	.....	.72	
1905—														
Rainfall.....	.....	.....	1.47	.01	.14	1.62		.11	.30	.21	.56	.35	1.53	

An inspection of the record shows an average temperature of 49 and 55 degrees for the months of April and May in 1904 and 1905. This is considered a good growing temperature for most cultivated crops. It is also a good growing temperature for apple scab fungus. The rainfall for the two months during 1904 was 2.04 inches — a sufficient amount of moisture to insure rapid growth. The same months of the following year (1905) shows a much heavier rainfall. 1.62 inches of rain fell in April and 1.53 inches during May making a total of 3.15 inches. It is also to be noted that there was nearly double the rainfall in May of 1905 as compared with the rainfall of the same month the previous year. During May, 1905, there were sixteen rainy, thirteen cloudy and five partly cloudy days. The almost continuous cloudy and rainy weather kept the atmosphere in a very moist condition. Since the greater number of winter spores are discharged from the capsules during the latter part of April and the first half of May the moist atmosphere and the good growing temperature were very favorable and the growth of the fungus was very marked. Such weather also causes a very succulent growth of foliage and the fungus is probably able to make a more speedy entrance into the tissues of the leaves and fruit.

PREVENTIVE METHODS.

The percent of increase as shown by the above table indicates that in order to raise a first class crop of fruit it becomes necessary to use preventive methods to control the disease. Since the fungus that causes the disease winters in the dead leaves it is evident that the destruction of as many of the fallen leaves as possible will materially lessen the number of winter spores set free in spring. Plowing the leaves under in the fall is perhaps the easiest method of getting rid of a greater number of them. This will not control the disease. The trees must be sprayed.

SPRAYING.

There are two methods of treatment followed in the different sections of the country in which apple scab occurs—the older method of applying some compound using water as a conveyor, and the newer method of applying various compounds reduced to a fine powder with some finely pulverized medium, usually lime dust, and applied with a pair of bellows or a dust sprayer.

In combatting apple scab properly prepared Bordeaux mixture has usually given excellent results. Dried Bordeaux mixture mixed with

lime dust has apparently given good results in some sections. Because of the contour of some orchards, the ease of hauling a dust sprayer over wet ground, the ease and rapidity of application and the promising results reported from other sections, a mixture of dried Bordeaux and lime dust (dust Bordeaux) was given a somewhat limited trial during the past season. The results have not been encouraging as shown by the following tables.

THE PLAN OF THE EXPERIMENTS.

In testing the value of dust Bordeaux as a preventive some trees were sprayed with dust Bordeaux, some with liquid Bordeaux (Bordeaux mixture), and others were kept as checks. Two orchards were selected for the tests—the orchard of the Agricultural Experiment Station in Whitman county, and the orchard of J. T. Woody in same county about thirty miles distant. Trees of uniform size and age in each case were selected. The greater number are located on northerly slopes on account of scab being more abundant in the more moist portions of the orchard.

EXPERIMENTS IN WOODDYS' ORCHARD.

A section of a young orchard of 215 trees, consisting of about 100 Ben Davis, 75 Jonathan and 35 Baldwin trees, and about 30 Ben Davis in an older one, were selected for the experiments. On April 26th, a part of the Ben Davis and a part of the Jonathan trees were sprayed with Bordeaux. One row of Jonathan, two rows of Ben Davis and part of the Baldwins were sprayed with Bordeaux mixture. The trees treated with dust Bordeaux received a second application on May 15th. The dust was applied in early morning when the dew was still on them and the air was still, the necessary conditions for applying dust. The trees sprayed with Bordeaux were given a second application two days later.

Near the close of the season the fruit on all the Baldwin trees was gathered in the absence of the writer and no record taken. A number of the Ben Davis and Jonathan did not bear or the crop was too small for comparison. The results obtained in this work, (the section of the young orchard) are tabulated to show the percent of scabby fruit on untreated trees and those treated with liquid Bordeaux and dust Bordeaux.

Variety	Sprayed with Liquid Bordeaux		Sprayed with Dust Bordeaux		Not Treated (Checks)	
	No. Trees	Per Cent Clear	No. Trees	Per Cent Clear	No. Trees	Per Cent Clear
Jonathan.....	3	97	36	9	18	1
Ben Davis.....	16	88	36	1	12	14

It is evident from this table that liquid Bordeaux and dust Bordeaux are not equally efficient when but two applications of each are made. Ninety-seven of per cent of the fruit on the Jonathan trees sprayed with liquid Bordeaux and 9 per cent of the fruit on trees treated with dust Bordeaux was free from scab. Dust Bordeaux is apparently a very poor preventive. Since the check trees yielded one per cent clear fruit, dust Bordeaux only protected 8 per cent against 96 per cent by the liquid Bordeaux.

The dust seems to be less efficient on the Ben Davis than on the Jonathan. Check trees show 14 per cent clear fruit, those treated with dust Bordeaux 16 per cent.

Twenty-eight trees of the Ben Davis variety in an adjoining older orchard were sprayed with liquid Bordeaux. Five trees were saved as checks. To get the per cent of gain two sprayed and two check trees were selected and the fruit counted on each. These trees were selected on account of being typical of all. In this case the sprayed trees yielded 95 per cent clear fruit while the checks gave 12 per cent clear fruit—a gain of 83 per cent. It is evident from this data that the results obtained in spraying the Jonathan and Ben Davis with the liquid Bordeaux in the above experiment are average results.

These experiments were conducted in this orchard by the request of the owner, J. T. Wooddy, to whom thanks are due for his hearty cooperation.

EXPERIMENTS IN STATION ORCHARD.

The station orchard is composed of numerous varieties. Each variety is represented by one to three individuals. Sixteen varieties that are very susceptible were selected for the experiment. When a variety was represented by three trees one was sprayed with liquid Bordeaux, one with dust Bordeaux, and the other kept as a check. In other cases a few trees were sprayed with liquid Bordeaux and others with dust Bordeaux, each time retaining one tree of each variety as a check. These trees were sprayed on the 28th, and 29th of April.

A second application was made on May 17th. Both the liquid and dust sprays were applied in the early part of the day when the conditions were best for the application of the dust. The results of these experiments are given in the following table:

Table Showing the Per Cent of Clear Fruit on Trees Sprayed with Liquid Bordeaux and Dust Bordeaux and Checks.

Variety	Liquid Bordeaux	Dust Bordeaux	Checks	Notes
Babbitt.....	75			Liquid Bordeaux protected 52-82 per cent of fruit
Kinnaird.....	52			
Wine.....	85		3	
Blood.....		4	2	Of the twenty trees included in this part of the experiment 10 were treated with dust. The spray protected 1-46 per cent or an average of 10 per cent. It is to be noted that the average on six of these trees was less than 1 per cent, while on the remaining the average was 24 per cent.
Hanny.....		24	5	
Maiden Blush..		1	14	
McNash.....		17	1	
Noble Savori...		62	16	
Paragon.....		0	0	
Rambo.....		27	26	
Red June.....		1	2	
Sops of Wine...		3	2	
Stone Eureka..		6	0	
Boyd.....	84	5	0	As shown by these comparisons every apple on checks was scabby. Dust protected 5 to 8 per cent and liquid 84 to 93 per cent.
Missouri.....	93	7	0	
Steptoe.....	86	8	0	
Average.....	81	12	5	

The averages show that on six varieties sprayed with liquid Bordeaux that 81 per cent of the fruit was protected while on the same number of check trees there was only .5 per cent clear fruit, showing a gain of 80.5 per cent clear fruit. The average per cent of clear fruit on sixteen varieties sprayed with dust Bordeaux show 12 per cent clear fruit while the checks only show 5 per cent clear fruit— a gain of 7 per cent. It is evident from these figures that liquid Bordeaux is several times more efficient than the same number of applications of dust Bordeaux.

SUMMARY OF EXPERIMENTS.

The results given in the above experiments include a total of 195 trees representing 18 varieties. Of the number 85 trees representing 15 varieties were sprayed with dust Bordeaux. The average per cent of clear fruit on these 85 trees was 13. On about 50 trees representing the same number of varieties that were not sprayed there was an average of 6 per cent clear fruit. This gives us an average gain of 7 per cent—the per cent of fruit protected by two applications of dust Bordeaux. On the other hand about 60 trees representing 8 varieties that

were sprayed with liquid Bordeaux showed an average of 89 per cent clear fruit to the tree. Since the unsprayed trees yielded 6 per cent clear fruit to leaves a difference of 83 per cent, the per cent of fruit protected by the liquid Bordeaux, nearly twelve times more fruit than was protected by the dust spray.

METHODS OF PREPARING THE SPRAYS.

LIQUID BORDEAUX.—The liquid Bordeaux was prepared in the usual manner by dissolving 6 pounds of bluestone in 25 gallons of water and slacking 4 pounds of good quick lime in a small amount of water and adding enough more to bring the amount up to 25 gallons. The two solutions were then poured together in a third vessel and stirred thoroughly and then strained to remove all particles of lime and other inert material. All the liquid Bordeaux used in the Station orchard was tested to determine if sufficient lime had been used to unite with all the bluestone. To test the mixture a few drops of a solution of ferro-cyanide of potash (one ounce to one half pint of water) were poured in a cup filled with Bordeaux. If a brown color appeared, more lime was added and the mixture thoroughly stirred. This process was continued till the brown color failed to appear. In making the tests new solutions were used each time. This test should be made each time a lot of spray is mixed. If the Bordeaux mixture does not have enough lime in it the fruit will be russeted.

DUST BORDEAUX.—In the preparation of the dust the Bird formula in the main (Mo. Bull. 60) was followed. Six pounds of bluestone were dissolved in a couple of gallons of hot water. Four pounds of good quick lime were slacked in a small amount of water and enough more water added to make two gallons of thick lime water. The two solutions were then poured together into a third vessel and the mixture thoroughly stirred, after which it was placed in a flour sack and as much of the water wrung out as possible. About 100 pounds of lime dust, all of which was sifted through a sieve 60 meshes to the inch was then placed in a shallow mortar box and the thick blue mass contained in the flour sack added. The lime dust and the blue mass was thoroughly mixed by using a garden hoe. Enough more lime was then added to dry the mixture. The mixture was resifted and enough more sifted lime dust added to make a bulk of 210 pounds. The dust was then ready for use.

The sifting and mixing of the dust Bordeaux is a very tedious and disagreeable task. Without the proper appliances the process is indeed a laborious one.

MACHINES USED IN APPLYING THE SPRAYS.

In applying the liquid spray three different spraying outfits were used. All gave good satisfaction. Any force pump that is in good working order and large enough to handle the needed amount of spray is all right. Both the vermorel and bordeaux nozzles were used. The former throws a cone shaped spray and the latter a fan shaped one. The matter of choosing a spray nozzle rests with the man doing the work.

The dust was applied by using the Cyclone Dust Sprayer. The Cyclone is manufactured by the Dust Sprayer Manufacturing Co., Kansas City, Mo., and the one used was purchased from that company.

STRENGTH OF SPRAYING PREPARATIONS.

In the preparation of liquid Bordeaux the formula 6-4-50 was used and in the preparation of the dust the 6-4-200. The best way to compare the strength of materials is to figure the amount of Bordeaux mixture contained in the water or lime dust applied on trees of the same size. It is shown below under the topic of Relative Cost of Sprays that one pound of dust and one gallon of liquid were used on each tree of the same size and age. One pound of dust contains a little less than 0.5 oz. of the dried compound formed by the union of lime and bluestone. Liquid Bordeaux contained 3.4 oz. of the compound to the gallon. Contending that the dried compound and the compound suspended in the water are of equal efficiency the liquid Bordeaux was 6.8 times stronger than the dust Bordeaux. The relative strengths used were largely decided upon by the cost of the sprays.

RELATIVE COST OF THE SPRAYS.

The following will serve to illustrate the relative cost of the two sprays:

DUST BORDEAUX.

6 pounds Bluestone at 7cts, - - -	\$.42
4 pounds Quick Lime at 1ct, - - -	.04
200 pounds Lime Dust at 1ct, - - -	2.00
<hr/>	
Total, - - - - -	2.40

LIQUID BORDEAUX.

6 pounds Bluestone at 7cts, - - -	\$.42
4 pounds Quick Lime at 1ct, - - -	.04
50 gallons water, - - -	.00
Total, - - -	.46

Relative Cost of Sprays and of Applying them.

Spray	Men	Teams	No. of trees	Time	Materials	Cost	Cost per tree
Dust.....	2	1	57	1 hr.	55 lb.	\$1.25	2 1-5c
Liquid.....	3	1	75	1 hr.	75 gal.	\$1.50	2c

The above data gives the cost of the first application only. While the experiment is a small one and the materials were used in small quantities the figures plainly show that when the work is done under the same conditions that the relative cost is nearly equal. When spraying is done on a larger scale and application of sprays is made from one side of the tree at a time instead of going around it considerable time will be saved thus making a corresponding difference in the cost of application.

SUMMARY

- 1—Apple scab is caused by a fungus. Page 3
- 2—There are two stages of the fungus—a summer stage and a winter stage. Page 3-4
- 3—The fungus passes the winter in the dead leaves of the apple. Page 3-4
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† and ‡ are out of print.